Tomographic Determination of the upper crustal structure in Bachu-Jiashi, Xinjiang autonomous region

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ABSTRACT :
A detailed tomographic image of the upper crustal structure in Bachu-Jiashi, Xinjiang autonomous region, is determined by using P- and S-wave arrival time, by Ts-Tp method proposed by author. Ts-Tp tomographic can eliminate influence of clock error on inversion result. The inversion results as following: A) P-Velocity at 2km depth is strongly horizontal heterogeneity. This phenomenon maybe is related to the uppermost sedimentary layer about 4km thickness. B) P-velocity between 5km and 14km depth suggests that there exist two high and conjugated velocity zone, one trending NE and the other NW. The NW high velocity zone is similar in the shape to the distribution of aftershocks. C) According to the relation of P velocity imaging and the faults of studied area, it is considered that the hidden Meigaiti-Xiasuhong fault pass through the crystalline basement and is a fault for Jiashi strong earthquake in 2003.

KEYWORDS:
seismic tomography, Ts-Tp method of seismic tomography, clock error, Bachu-Jiashi area, upper-crust velocity structure

0.INTRODUCTION

The 24 February, 2004 Ms6.8 earthquake occurred on the border of Bachu and Jiashi counties in Xinjiang autonomous region, western China(Hereinafter is call the Bachu-Jiashi earthquake). The earthquake caused direct loss about 139.8 billion RMB and killed 268 people. The earthquake-caused loss is most severe in Xinjiang autonomous region.

Bachu—Jiashi area in the south of Tian Mountain is the region with strong geological structure deformation and is about 30km from Jiashi strong earthquake swarm, which occurred within a very small area and a very short period of time(1997~1998) in Jiashi of Xinjiang autonomous region and included 9 shocks(Ms>6.0). Moreover, aftershock in Bachu-Jiashi area is ample. Bachu—Jiashi area is very worthy to study seismic gestation and have attracted attention of many seismologists around the world(Zhu et al, 1998; Zhou et al, 1999, 2000; Liu et al, 2000, Li et al, 2002; Lai et al,2003,2006;Yang et al, 2002;Xu et al, 2006; Zhang et al, 2002; Guo et al, 2002). Bachu-Jiashi is on the edge of China and the ability of seismic observation in this area is very poor. There are only four seismic observation around Bachu-Jiashi earthquake within 250km. In order to make clear the space-time distribution of aftershock sequence, China Earthquake Administration decided to enchanced observation and sended Mobile Emergency Observation Team to setted up mobile seismic station network, which can transport real-time waveform data. The waveform data were beginning to be recorded on 12 March and the observation lasted about 50 days. Finally, a high-quality data were obtained(Yangjianshi,2003), which is useful to tomographic determination of the upper crustal structure in Bachu-Jiashi.

1.STUDY AREA SUMMARY

Bachu-Jiashi area are located in the west margin of Talimu basin and on the intersection of the southern Tian Mountain & the pamir-west Kunlun seismic belt. Here is collision between cusp of Pamir of Indian plate and Eurasian plate and the frontier area of southward subduction of Tarim basin. Hence, tectonic movement is intensive in here. Basic information of this area is given in figure 1(Li SongLing, 2002). There are some burried faults in study area , including Keping,Yangdaman and Maigaiti faults. However, at present, both research and fieldwork show that there are no structure features about these faults stretching to the surface in focal region, including 1997-1998 strong earthquake swarm area. According to the data of petroleum exploration, Maigaiti fault is located in the southeast of focal region, and Yangdaman fault in the westeast; Maigaiti-Xiasuhong fault pass through the crystalline basement; Yangdaman fault is a burried fault, it still wasn't clear whether or not faults stretche to focal region.

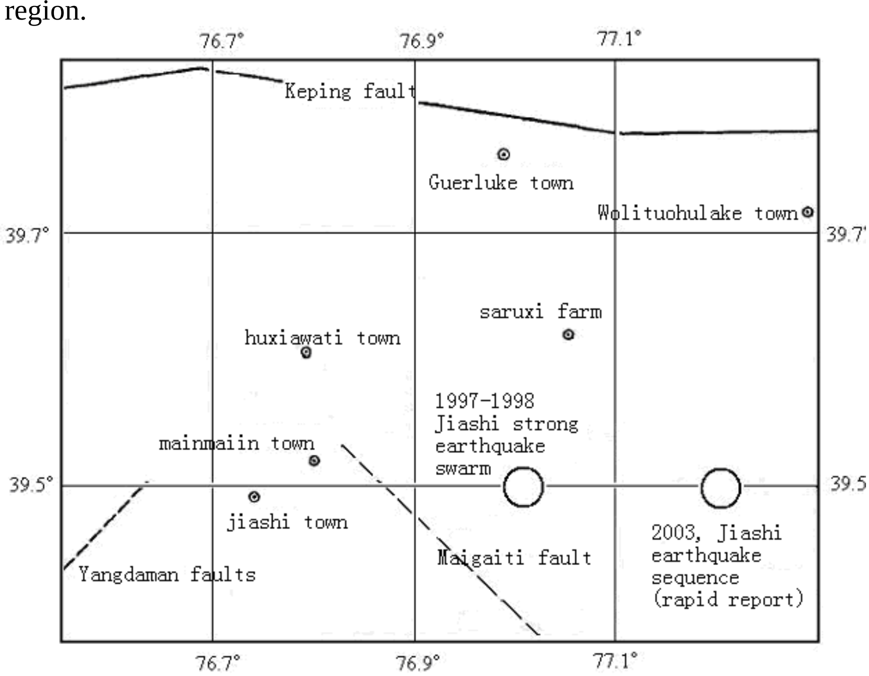

Figure 1 the distribution of Jianshi earthquake and local tectonic map(LiSonglin, 2002)

2.DATA

Mobile Emergency Observation Team, attached China Earthquake Adiministration, setted up mobile seismic station network consist of five 3-component Feedback Broadband Seismometers (FBS-3B), equipping with 24 bit data acquisition (EDAS-C24), both made by Beijing Gangzhen Mechanical & Electronic Technology CO., LTD. The aperture of station is about 70km along E-W direction and about 30km along S-N direction. Beside the data recorded by mobile seismic station network, the data of aftershock, which is recorded by four permanent seismic station(Kashi, Bachu, Hetian, Wushi seismic stations), are used to inverse the upper crustal structure in Bachu-Jiashi.

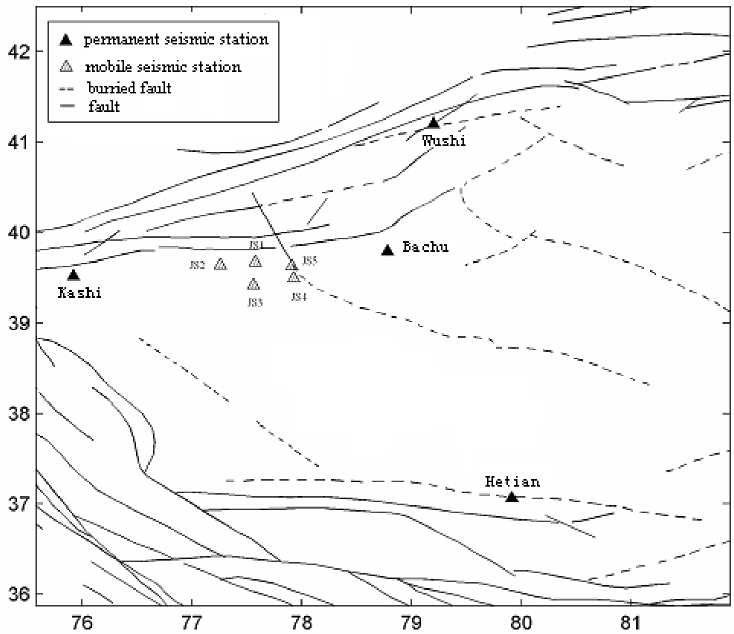

Figure 2 the distribution of mobile & permanent seismic station

Travel time data of P- and S-Velocity, recorded by above mentioned nine seismic station, is collected, the part of data is collected by HuangYuan. 1722 earthquakes were selected，meeting the requirement that arrival time residual is less than 2.0 second. Earthquakes were relocated by the double-difference method before tomograph.

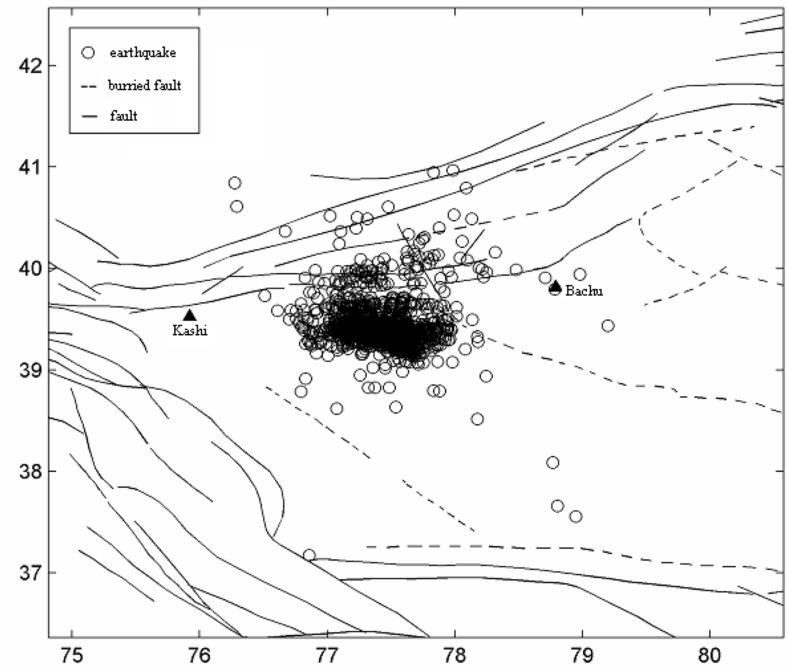

Figure 3 the distribution of aftershock

3.METHODOLOGY

In general, underground structure is consist of continuous body and discontinuity. In this study, a three-dimensional grid nets was used to express the continuous body under study area, in other words, we take velocity at grid nodes as unknown parameters and calculate a velocity at any point by using a linear interpolation function; a two-dimensional grid net was used to express the discontinuity. When in continuous body, ray path is calculated on the pseudo-bending (Um & Thurber, 1987); when through discontinuity, ray path is calculated on Snell's law (Zhao et.al, 1992). The large and sparse system of observation equations is solved by using the LSQR algorithm (Paige & Saunders, 1982).

From ith earthquake to jth station, arrival time is:

$$T^{i,j} = T_i^0 + \int_{L^{i,j}} ds^{i,j} n(r) \quad \text{(3.1)}$$

where T_i^0 is the origin time of ith earthquake, and $L^{i,j}$ is the ray path from ith earthquake to jth station, and $n(r)$ is slowness along the ray path. Arrival time residual is defined as $\delta T^{i,j} = T_{obs}^{i,j} - T_{cal}^{i,j}$, is written in matrix form:

$$b = Gx \quad \text{(3.2)}$$

where b is vector of arrival time residual, and G is coefficient matrix, and x is vector of unknow parameter, i.e. model parameter variables.

According to above-mentioned method, P- and S-velocity is calculated simultaneously in this paper, and two matrixs is obtained. a large inversion matrix is obtained by Subtracting of two matrix. By this way, impacting of clock error on inversion result is eliminated.

4.RESULT AND ANALYSIS

Figure 4 show one-dimensional velocity model modified slightly from the research results by ZhanXiankang(2002), which was used as initial velocity model. Moho depth in study is about 50 km according to research result by LiuQiyuan(2000).

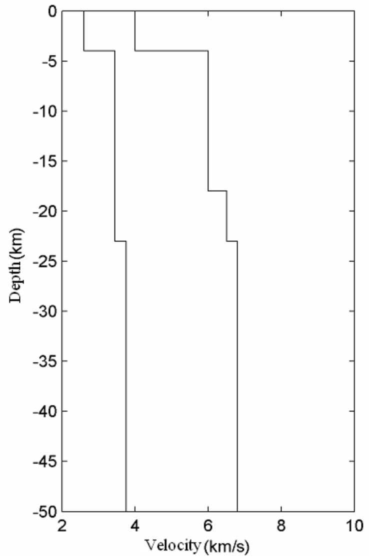

Figure 4 Initial 1-D velocity model

Figure 5 is the distribution of P-wave rays in this study in plane view. Our checkerboard tests with smaller grid spacings show that the spatial resolution is 0.15° along E-W direction, and 0.05° along S-N direction.

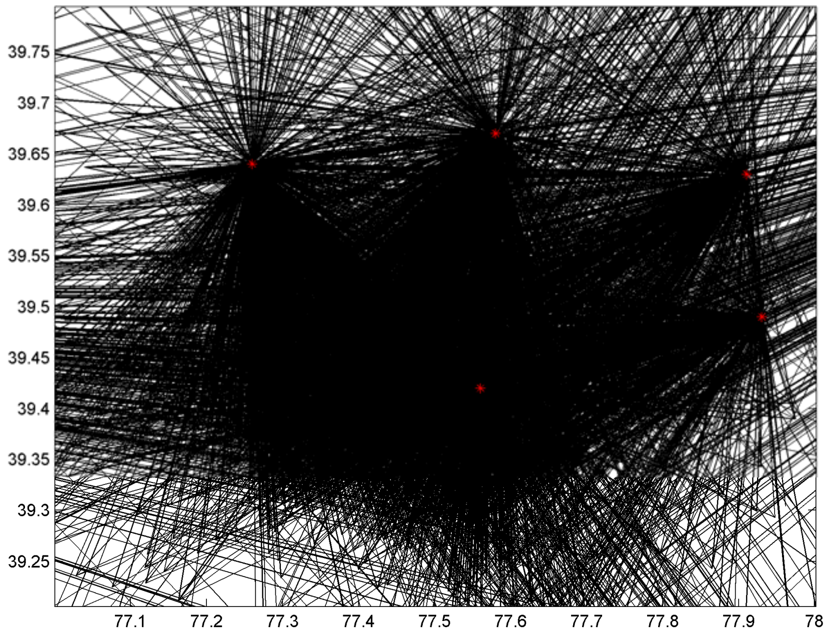

Figure 5 the distribution of P-wave ray path in plane view

Figure 6 is the P-wave velocity image at each depth slice(in percent from the average velocity). Different color denote different value of P-wave velocity, blue represent high value and red represent low value. Black dots show aftershock of the Bachu-Jiashi earthquake, the size of dot represent the magnitude of aftershock.

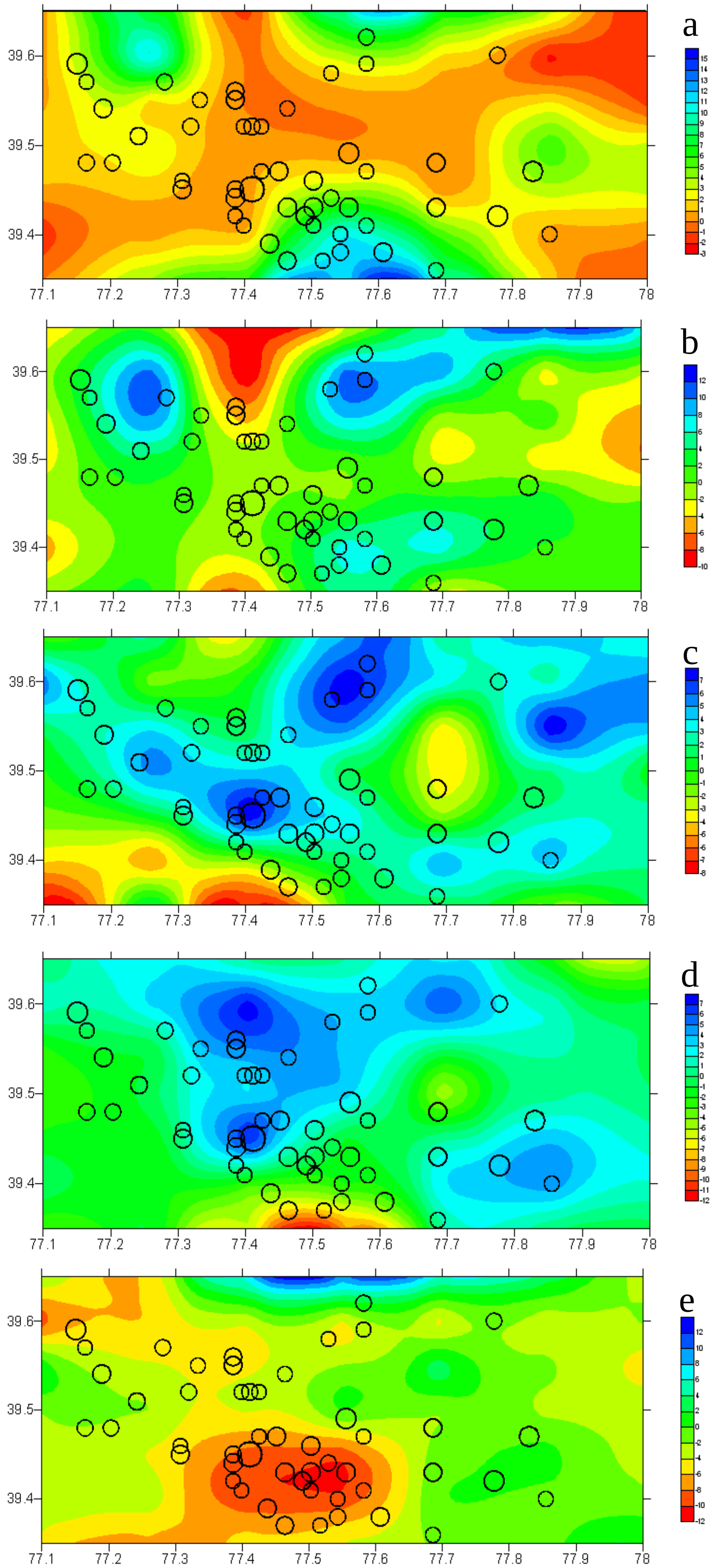

Figure 6 the P-wave velocity image at each depth slice
((a) 2km depth , (b) 5km depth, (c) 8km depth , (d) 14km depth, (e) 22km depth)

There are large area of low value at the 2km depth slice, alternated with high value. The slice show a strong horizontal heterogeneity, there is no other regularity to be look for. This phenomenon maybe related to the uppermost sedimentary layer proximal 4km thickness. From 5km depth, there are some regularity for the changing of figure. Two high value areas in 5km depth slice is extending. At 8km depth, left-hand high value area extend along n-w direction and form nw-trending band of high value, and other one extend along nnw and form nnw band of high value. This two bands intersect at 39.45° N and 77.4° E, forming conjugate high value band. At 14km depth, the conjugate high value band is clearer. Meanwhile, N-W direction band moves northward, this suggests that N-W direction band dip northward with depth. When Ms≥3.5 aftershock were projected to each depth slice, it's will be found that aftershock distribute along N-W direction high value band, especially in 8km and 14km depth slice, most of aftershock is in or near to N-W direction band. Strong body earthquake-generating model(MeiShirong et al, 1995) hold that high velocity body(strong body) is important condition for strong stress concentration. YangZhuoxing et al(2002) inverse the upper crustal structure in Jiashi, where is more west than our study area and in where Jiashi strong swarm occurred from 1997 to 1998. The result show that Jiashi earthquakes distribute along transition zone of P-wave high velocity and low velocity, forming nnw band. YangZhuoxing et al(2002) hold that the difference in geographical structure is the most direct reason that cause occuring of Jiashi earthquake.

There is no outcropped fault obviously in study area. According to the data of petroleum exploration, there are two inferred basement faults around study area, Maigaiti and Maigaiti-Xiasuhong faults. The northern section of Maigaiti-Xiasuhong fault is consist of two almost parallel branchs along nnw, the position and shape of the east branch is basically identical with P-wave high velocity band. XuZhaofan et al(2006) inferred that buried layer of Maigaiti-Xiasuhong faults is about 4.5km, same depth with P-wave high velocity band. Considing the relationship of Maigaiti-Xiasuhong faults and P-wave high velocity band, we deduce that P-wave high velocity band is most likely caused by Maigaiti-Xiasuhong faults. XuZhaofan et al(2006) considing that Maigaiti-Xiasuhong faults don't pass through the crystalline basement(about 9km depth) and a generating fault for Jiashi earthquake. However, our result show that shape of the P-wave high velocity band is still clear at 9km depth. Our result is that Maigaiti-Xiasuhong faults most likely pass through the crystalline basement. According corresponding relation of the P-wave high velocity band and Maigaiti-Xiasuhong faults, the P-wave high velocity is direct reason that cause occuring of the Bachu-Jiashi earthquake, and Maigaiti-Xiasuhong faults is a generating faults for the Bachu-Jiashi earthquake.

5.CONCLUSIONS

By tomographic Determination of the upper crustal structure in Bachu-Jiashi, we get a results as following:A) P-Velocity at 2km depth is strongly horizontal heterogeneity. This phenomenon maybe is related to the uppermost sedimentary layer about 4km thickness. B) P-velocity between 5km and 14km depth suggests that there exist two high and conjugated velocity zone, one trending NE and the other NW. The NW high velocity zone is similar in the shape to the distribution of aftershocks. C) According to the relation of P velocity imaging and the faults of studied area, it is considered that the hidden Meigaiti-Xiasuhong fault pass through the crystalline basement and is a fault for Jiashi strong earthquake in 2003.

6.ACKNOWLEDGEMENTS

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